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Comparative study of physico-chemical parameters with national and international standard and the insect community of Erelu Reservoir in Oyo town, Oyo State, Nigeria

Popoola K. O. K[1*], Sowunmi A. A.[1] and Amusat A.I.[2]

[1]Department of Zoology, Faculty of Science University of Ibadan, Ibadan, Nigeria.
[2]Department of Science Laboratory Technology, Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria.

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Assessment of water bodies is very crucial to determine its quality and proffer solution before it has an adverse impact on its biota and direct users of the water body. Insect communities and physico-chemical parameters in comparison with national and international criteria of Erelu Reservoir were investigated to determine their impacts on insect community of the reservoir. Water and insect macro-invertebrates sampling was done once in every month from June 2013-May 2015 from each station of Erelu Reservoir. Insects were collected using net of mesh size of 250 µm to swap the surface of water. Insects collected were identified with standard identification guide. Water samples were analyzed using standard method. Data collected from physico-chemical parameters were analysed using descriptive statistics. Relationship between physico-chemical parameters and insect macro-invertebrates was determined using pearson's correlation coefficient (r). Species diversity, evenness and richness were examined using Margalef, Shannon Weinner and Equitability indexes. The results of physico-chemical parameters revealed that turbidity values (12.48±3.00 Ntu) were higher than the required limits of WHO and NESREA (5.00 Ntu) criteria, while nitrate (1.14±0.15 mg/L) and phosphate (0.21±0.08 mg/L) values were below the recommended standard of NESREA (9-10 and 3.50 mg/L). A total of 4 orders (Coleoptera, Diptera, Hemiptera and Odonata) having 72,276 individual insect macro-invertebrates were collected. Hemiptera were the most abundant (91.57%) among the insects encountered. Transparency had positive significant relationship with Hemiptera (0.880) and Odonata (0.675), Ca^{2+}, Mg^{2+}, DO, TDS, NO_3^-, TA. Turbidity, pH, Temp. and EC had negative correlation with orders of Coleoptera, Diptera and Odonata at (P<0.05). Turbidity had direct correlation with Diptera (0.0731) at (P<0.05). The present study revealed that the water quality parameters value were within standard limits and had little impacts on the insect abundance and richness. The low nutrients and high turbidity indicate low productivity of water body, thus, tending towards deterioration if proper management of the reservoir is not adopted.

Key words: Water quality parameters, macro-invertebrates, richness, diversity, nesrea, turbidity.

INTRODUCTION

Limnology can be described as the study of all physical, chemical and biological characteristics of a freshwater body. Physical factors include water level fluctuation, air and water temperature, direction of wind, light, water current, transparency/turbidity while chemical factors include oxygen concentrations, alkalinity, pH, with biological parameters such as bacteria, plankton assemblage, benthic and insect macro-invertebrates (Adebisi, 1980). Physicochemical properties have great effect on the biological entity of any aquatic environment especially when there is aquatic ecosystem disturbance like leakage of septic tank into water system, fertilizer and pesticides runoff, industrial effluents and wastes from various sources could impact aquatic ecosystem and their biotic community (Holden and Green, 1960; Reese and Voshell, 2002). However, monitoring of the aquatic system to understand the level of perturbation by anthropogenic activities or other sources is very crucial to ensure proper management. This management could be done by monitoring the physico-chemical parameters and see how deviated they are from the standard values by using regulations set by either national or international bodies (Rosenberg and Reese 1993). The purpose of these regulations is to restore, enhance and preserve the physical, chemical and biological integrity of the nation's surface waters and to maintain existing water uses.

Aquatic insects comprise diverse and ecologically attractive group of animals in freshwater system. They are known to play a significant role in an ecosystem such as sources of food for amphibians, fishes and aquatic birds. They are not only serve as energy link but also enable cycling of nutrients through their divisional feeding class as shredders, deposit collectors, filter feeder and predators (Lamberti and Moore, 1984; Balaram, 2005). Aquatic insects spend their live or part of their live in the aquatic system (Arimoro et al., 2007a). However, the abundance of a trophic group in an ecosystem indicates variety of quality of the system. The higher abundance of shredders and collectors trophic group is an indicator of better quality of ecosystem than the one dominated by predators (Meyer, 2006). The use of aquatic insect biomonitoring is very important to a biologist because they are very sensitive and respond to both natural and human-induced changes in the environment (Ndaruga et al., 2004).

Furthermore, the use of aquatic insect in evaluating water quality cannot be overlooked and also the outcome provides information to environmental managers and decision makers to take justifiable actions as regards to the state and quality of water bodies. Studies have been carried out on the impact of water quality parameters on insect community of some streams and reservoir. A few of this documented work includes that of Samweel and Nasir (2014) who reported aquatic insects increase with decrease in temperature in India. Popoola and Otalekor (2011) in Awba Stream and Reservoir in Ibadan, who reported greater effects of water quality parameters on the abundance and distribution of insects. Sanjida et al. (2015) in Bangladesh reported highest number of order Ephemeroptera and Trichoptera in river Shitalakhya as a result of good water quality parameters. Ebenebe et al. (2016) also reported that aquatic insects' abundance and distribution are affected by physico-chemical properties of in Awka, Nigeria. This study was designed to investigate the water quality parameters in relation to national and international standards and their effects on the assemblage of insect community of Erelu Reservoir in Oyo town, Oyo State, Nigeria.

MATERIALS AND METHODS

Description of study area

The study area for this research is Erelu Reservoir located in Oyo town, Oyo State, Nigeria. This reservoir was built in 1961 on Aawon River along Oyo/Iseyin road. The impoundment of the dam is 161.07 ha and the catchment area is 243.36 km. The reservoir supplies drinkable water to Oyo and its environs. The reservoir is surrounded by vegetation which is ever green and interspersed with grasses. Some of the trees there are *Parkia biglobosa, Psidium guajava, Azadirachta indica,* Eagle, Heron and Ducks do visits the reservoir. Reservoir banks are covered with *Pisitia stratiotes, Commelina benghalensis, Ipomoea aquatica* e.t.c. Fish fauna found in the reservoir includes *Tilapia zillii, Hepsetus odoe, Mormyrus rume* e.t.c. The reservoir has an average mean temperature of 27°C, annual mean rainfall of 591.6 mm and mean annual relative humidity of 77.16% (Figure 1 and Table 1).

Water samples collection and analysis

Water samples for physico-chemical parameter were collected once in a month (June 2013-May 2015) from each sampling station, with 4 L plastic containers. Containers were pre-washed with nitric acid each time to remove any form of contaminants. The water samples were taken to Erelu laboratory for immediate analysis to retain its quality. The transparency and temperature were determined *in-situ* with seechi-disc and mercury in-glass thermometer. Dissolved Oxygen (DO), Hydrogen ion concentration (pH), Electrical Conductivity (EC), Total Dissolved Solids (TDS) were examined using Extech multimeter kit (Model: DO600 and EC500). Calcium ion, Magnessium ion, Total alkalinity (TA), Biological Oxygen Demand (BOD) were measured using standard titrimetric methods while Nitrate (NO_3^-) and phosphate (PO_4^-) were determined using Hannah bench photometer (Model: H183200) and Atomic Absorption Spectrophotometer (Model: Analyst Al0 PGP).

Aquatic Insects Sampling and Identification

Adult insects were collected from water surface of each sampling station once, using a dip-net of mesh size 500 µm. Insects collected were preserved in 70% alcohol in plastic containers. All the samples collected from all stations were taken to Erelu laboratory for identification using microscope and standard identification

*Corresponding author. E-mail: kokpopular@gmail.com.

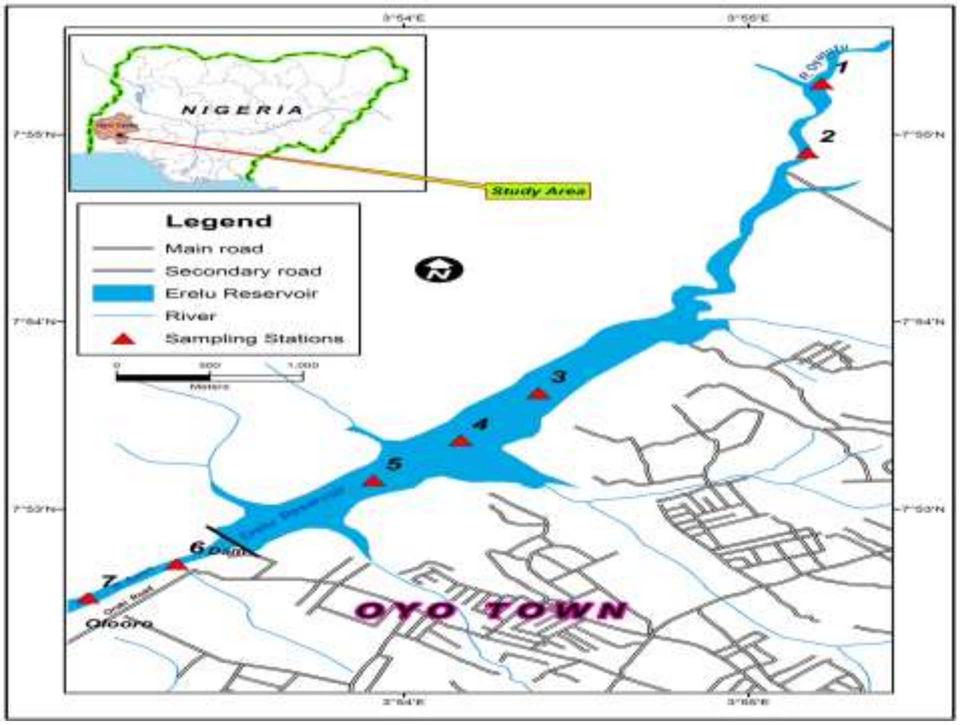

Figure 1. Map of the seven sampling stations along Erelu reservoir in Oyo town.

Table 1. Description of the sampling sites.

Sampling stations	Description of the locations	Latitude	Longitude
Inlet (2-sample stations at the entrance of the rservoir)	This is located at Oyatutu, 5km away from the reservoir sandy contaminated with fertilizer due to farming activities	3°54'7.0"E	7°53'21.8"N
Reservoir (3-sample stations within the reservoir)	This is located within the reservoir, muddy substratum, and landing stations for fishermen	3°5'21.2"E	7°52'42.8"N
Outlet (2-sample stations at the exit of the reservoir)	Downstream stations, located in Odo Olooro where the reservoir exists into the river sandy substratum and impacted with human activity	3°5'12.6"E	7°55'5.8"N

Water samples collection and analysis.

guides of Meritt and Cummins (1996), Pennak (1978), Needham et al. (2000) and Heckman (2002); the samples were identified to species level.

Data analysis

Data collected were analyzed using Microsoft excel 2007 to determine descriptive statistics like mean and standard error of mean. Pearson's correlation Coefficient (r) was used to determine relationship between physico-chemical parameters and insect macroinvertebrates collected from Erelu Reservoir. Diversity and other indices were examined using the following formulas:

Margalef's Diversity Index measures the richness of the species (d)

$$= \frac{S-1}{\ln N}$$

Where, S=no of species, N = Total no of organisms
ln= Neutral or Naperian logarithms

Shannon Wienner's Index was used to determine the abundance of species of insects (H) =

$$\frac{N \log N - \sum f1 \log f1}{N}$$

Equitability measures how evenly distributed are the organisms in the study sites

$$(J) = \frac{H}{LogS} = \frac{H}{H\max}$$

where, H= Shannon Weiner's Index

Table 2. Comparison of physico-chemistry of study area with national and international criteria.

Parameter	Reservoir inlet	Main reservoir	Reservoir outlet	W.H.O limit	NESREA limits	SON limits
Transparency (cm)	**49.96±2.39** 22.56-85.00	**84.81±1.48** 70.00-120.00	**49.29±2.62** 22.00-90.00	–	–	–
Turbidity (Ntu)	**11.59±2.11** 0.00-64.70	**10.18±1.91** 0.00-66.80	**12.48±3.00** 0.00-101.50	5.00	5.00	5.00
Temperature (0c)	**28.44±0.23** 25.50-32.60	**28.48±0.18** 25.50-31.60	**28.58±0.24** 25.40-31.80	24-28°C	32.00	
Calcium ion (mg/L)	**17.73±1.15** 2.44-35.20	**16.39±0.79** 2.93-32.00	**17.60±0.98** 2.93-29.60	<15.00	180.00	_
Magnesium ion (mg/L)	**7.51±0.90** 0.62-34.00	**7.99±0.81** 0.34-30.00	**7.57±0.95** 0.48-26.00	30-150	40.00	0.20
Phosphate (mg/L)	**0.09±0.02** 0.01-0.48	**0.13±0.04** 0.01-2.73	**0.21±0.08** 0.01-2.73	0.10	3.50	100
Nitrate (mg/L)	**0.63±0.11** 0.00-2.69	**1.14±0.15** 0.00-3.89	**0.59±0.10** 0.00-0.43	50.00	9-10	50.00
Dissolved oxygen (mg/L)	**8.46±0.25** 3.96-14.6	**8.32±0.16** 3.36-14.00	**8.43±0.19** 6.02-12.20	4-10	6.00	_
Biological oxygen Demand (mg/L)	**1.25±0.22** 0.00-7.03	**1.09±0.16** 0.10-6.77	**1.23±0.21** 0.01-7.38	4.00	3.00	_
Hydrogen ion concentration pH (mg/L)	**7.37±0.06** 6.64-8.43	**7.34±0.05** 6.60-8.60	**7.48±0.06** 6.80-8.20	6.5-8.5	6.5-8.5	6.5-8.5
Total Alkalinity (mg/L)	**98.81±5.21** 48.00-176.00	**101.50±4.19** 30.00-174.00	**93.71±4.80** 30.00-160.00	100	500	100
Total Dissolved Solid (mg/L)	**136.01±13.82** 14.00-486.00	**139.89±10.75** 22.00-465.00	**146.16±13.72** 26.00-476.00	1000	1200	500
Conductivity (µs/cm)	**198.72±19.84** 11.43-689.00	**204.81±15.58** 31.43-664.00	**216.26±19.95** 37.14-676.00	1000	-	1000

Keys: WHO=World Health Organization
NESREA=National Environmental Standard and Regulation Enforcement Agency
SON=Standard Organization of Nigeria.

Hmax= maximum possible diversity value given are LogS.

RESULTS

Physico-chemical characteristics of Erelu reservoir in comparison with standard criteria

The mean values of physico-chemical parameters of each station are presented in Tables 2 to 5. The results revealed that transparency values were higher in the reservoir station (84.87±1.48) cm, while turbidity values were higher in the inlet (11.59±2.11) Ntu and outlet stations (12.48+300) Ntu. All the three stations were also more than permissible limits. Means values of temperature were uniform in the three sampled stations with highest values of 32.60°C. Ca^{2+} was recorded

Table 3. Abundance of species of insect encountered in Erelu reservoir.

Order/Species	Inlet	Reservoir	Outlet	Total
COLEOPTERA				
Gyrinus substriatus	526	554	1230	2,310
Sphaeridium scarabeoides	03	-----	01	04
Cyphonocerus ruficollis	149	2985	30	3,164
Hydaticus sp.	------	01	------	01
Dineutus sp.	------	02	27	29
Dytiscus sp.	01	03	-----	04
Total				**5,512**
DIPTERA				
Syrphid sp.	01	------	-----	01
Horsefly larva	03	02	-----	05
Total				**06**
HEMIPTERA				
Appasus sp.	20	47	23	90
Gerris sp.	230	736	138	1,104
Notonecta sp.	7,040	23,963	5,893	36,896
Velia capai	72	162	1,379	1,613
Ptilomera sp.	63	25	93	181
Hydrometra sp.	118	126	727	971
Corixa sp.	4,419	14,995	5,720	25,134
Cylindrothetus sp.	93	16	72	181
Ranatra sp.	01	04	02	07
Dytiscid larva	01	01	-----	02
Lethocerus sp.	----	----	01	01
Lacotrephes sp.	----	01	----	01
Total				**66,181**

smaller values in the reservoirs (16.39±0.79 mg/L) compared to other stations while Mg^{2+} had highest value in the reservoir than values recorded in other stations. The values of Ca^{2+} (17.73±1.15 mg/L) were higher than World Health Organization (<15 mg/L) limits but lower than the limits of National Environmental Standards and Regulation Enforcement Agency (180 mg/L); while the values of Mg^{2+} (0.01-2.73 mg/L) were within the permissible limits of WHO (0.10 mg/L) and NESREA (3.50 mg/L) but lower compared to that of Standard Organization of Nigeria (SON) (100 mg/L). Phosphate and Nitrate values were lesser in all stations compared to permissible limits of NESREA and SON. DO, pH, BOD values were higher at the inlet and outlet stations compared to the reservoir station. The values recorded for the three parameters fall within the required limits of W.H.O. The pH mean values were within neutral to alkaline in all stations and also fall within the permissible level of all standard mentioned in this study.

Total alkalinity (TA) mean values were higher at inlet (98.81± 5.21) mg/L and reservoir stations (101.50±4.19) mg/L compared to outlet station (98.71±4.80) mg/L value. Mean values of Total Dissolved Solids (TDS) recorded low values at the reservoir and outlet stations (136.01±13.82) mg/L but high values were recorded at the reservoir and outlet stations (139.89±10.75) and (146.16±13.72) respectively. Electrical conductivity also revealed inlet station to have lower mean value (198.72±9.84) µs/cm while the two other stations had higher mean values (204.81±5.58) µs/cm at reservoir and outlet (216.26±19.95) µs/cm, respectively. Total Dissolved Solids, Electrical conductivities fell within permissible level of WHO, NESREA and SON limits except TA that had higher values slightly more than the accepted values of WHO and SON in the reservoir stations.

Insect community of Erelu reservoir

The abundance of species insect community of each station and for the entire study area (pooled data of the

Table 4. Abundance of species of insect encountered in Erelu reservoir continues.

Order/Species	Inlet	Reservoir	Outlet	Total
ODONATA				
Aeshna sp.	03	08	05	16
Libellula sp.	----	25	03	28
Miathyria sp.	11	30	02	43
Ischnura sp.	16	31	17	64
Ischnura pumilio	07	24	13	44
Ischnura elegan	01	01	03	05
Ischnura verticalis	----	02	06	08
Sympetrum fonscolombii	05	46	04	55
Ceriagrion glabrum	01	16	01	18
Ceriagrion tenellum	02	21	----	23
Orthetrum sp.	----	08	01	09
Selysiothermis nigra	04	15	----	19
Trithemis kirbyi	15	73	16	104
Trithemis annulata	09	63	12	84
Aeshna mixta	06	21	04	31
Cordulegaster sp.	01	01	01	03
Diplacodes sp.	01	11	02	14
Lestes sp.	----	01	02	03
Libellula quadrimacula	03	03	-----	06
Total				**577**

Table 5. Overall Insect community encountered in Erelu reservoir during sampling.

Orders	Inlet	Reservoir	Outlet	Total (Pooled data)
	Abundance	**Abundance**	**Abundance**	**Abundance**
Coleoptera	679	3545	1288	5,512 (7.63)
Diptera	04	02	_	06 (0.01)
Hemiptera	12057	40076	14048	66181 (91.57)
Odonata	85	400	92	577 (0.80)
Total	**12,825**	**44,023**	**15,428**	**72,276**

three stations) is presented in Tables 4 and 5. Reservoir station had 44,023 individual, while inlet stations had 12,825 and outlet station, 15,428 individual; totaling 72,276 individuals, respectively. The pooled data showed that Hemiptera had highest percentage abundance (91.57%), followed by Coleoptera (7.63%). A total of four orders 36 species were encountered during this study. Relationship between the physico-chemical parameters and insect community of Erelu reservoir is presented in Table 6.

Pearson's correlation coefficient (r) revealed that transparency had a strong positive significant (p<0.01) relationship with Hemiptera while odonata related significantly also (*p*<0.05) with transparency. Turbidity correlated positively (p<0.05) with Diptera. DO, TDS Temperature and EC had inverse relationship with Diptera while turbidity, Mg^{2+}, NO_3^- , DO, BOD and pH related negatively with order Coleoptera. Hemiptera had positive but insignificant relationship with turbidity, Mg^{2+}, TDS, TA and Electrical Conductivity (EC) respectively. Order Odonata had inverse insignificant correlation with Ca^{2+}, NO_3^-, TDS, Temperature and EC respectively.

Ecological indices of the insect community are presented in Table 7. Shannon index showed Coleoptera (0.9792) to be more diverse, followed by Hemiptera (0.8553), Odonata (0.8451) and Diptera (0.8151). Margalef richness index revealed that orders of insect were very low in richness as in Diptera (0.3322), Coleoptera (0.2412), Hemiptera (0.2414) and Odonata (0.3361) consecutively. Equitability index showed that all orders of insects are equally distributed while Jaccard similarity index revealed that orders have similar species

Table 6. Pearson's correlation coefficient (r) between physico-chemical parameters with insect macroinvertebrates abundance of Erelu reservoir.

Parameter	Diptera	Coleoptera	Hemiptera	Odonata
Transparency (cm)	0.300	0.396	0.880**	0.675*
Turbidity (ntu)	0.731*	-0.431	0.201	0.294
Calcium ion (mg/L)	-0.101	0.115	0.158	-0.565
Magnesium ion (mg/l)	0.416	-0.056	0.266	-0.291
Phosphate (mg/L)	-0.358	0.122	-0.382	0.303
Nitrate (mg/L)	0.143	-0.014	0.215	-0.423
DO (mg/L)	-0.316	-0.101	-0.417	0.252
BOD (mg/L)	0.425	-0.524	-0.092	0.366
TDS (mg/L)	-0.393	0.316	0.093	-0.480
Total Alkalinity (mg/L)	0.112	0.166	0.329	-0.344
Ph	0.029	-0.596	-0.475	-0.139
Temperature (°C)	-0.590	0.446	-0.089	-0.428
Conductivity (µs/cm)	-0.372	0.297	0.110	-0.486

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 7. Ecological indices of insect macro-invertebrates in the study stations of Erelu reservoir.

Diversity Indices	Diptera	Coleoptera	Hemiptera	Odonata
Shannon Wiener index H	0.8151	0.9792	0.8553	0.8451
Margalef richness index (d)	0.3322	0.2412	0.2414	0.3361
Equitability index (J)	0.7399	0.8913	0.6584	0.7856

in the study area.

DISCUSSION

The highest transparency values recorded in the reservoir station than the inlet and outlet station values might be attributed to less input of dissolved solids into the reservoir. The present study also justified the reason for high values of turbidity in inlet and outlet stations of the reservoir which may be due to the stations being the recipient of more dissolved particles either from air or during flood. Turbidity values that were more than permissible limits reflect high level of suspended particles in the reservoir. Ebenebe et al. (2016) also recorded similar observation. The uniform values of temperature recorded across stations may be due to shallowness of sample water collected from each station. The present study revealed temperature range of 25.40-31.80°C which may be due to tree shade in the studied reservoir and low organic input which can generate heat during microbial degradation of organic substances. This result falls within the temperature range of tropical reservoirs and is in accordance with the report of Popoola and Inwang (2016) who reported temperature range of 25.18-31.40°C in Alaro stream, Ibadan.

The high values of calcium ion recorded at inlet and outlet stations indicated its presence in a good proportion which indicates that there is release of calcite from the water base or waste input that contains calcium salt than that of the reservoir station. This study contrasts that of Oyedibu et al. (2016) and Solanki (2012) who reported highest values of calcium ion in their study area. The inadequacy of calcium in water body was related to cause osteoporosis, kidney stone, colorectal cancer, hypertension in human if such water is taken. Mg^{2+}, concentration that falls within the limits of WHO and NESREA indicated low usage of organic fertilizer from farm land because is one of the additives and may be reasons for its right proportion in the body of water studied. Highest value range of Mg^{2+} concentration was reported by Solanki (2012).

The less values of nitrate and phosphate obtained in all stations is indicative of low nutrients in the water body. This could be attributed to low anthropogenic input into the reservoir which reduces algal bloom that enables aeration of the water body. Similar observation was noted by Jain et al. (1996) who similarly reported low phosphate and Nitrate values in the Halali reservoir, India and related it to low nutrient that leads to less pollution of the water body. Ghulam et al. (2014) corroborated the present study by reporting low phosphate value in Zhob

River, Pakistan. The present result of nitrate departed from that of Solanki (2012) and Ebenebe et al. (2016) that reported high values of nitrate in their studied areas.

The DO and BOD values that were high in the inlet and outlet stations may be due to low level of water in the stations which absorb ambient air and sink easily compared to the large volume of water in the reservoir, while low DO in the reservoir station could be associated with fullness of the water that leads to water stratification. The DO will circulate well on the surface of water compared to the middle layer and base of the water body. The present result agreed with the report of Francis et al. (2007), Oyedibu et al*.* (2016) and Shubam et al*.* (2017) who reported low BOD and DO in their study sites.

The present study revealed neutral to alkaline values of pH which is within the acceptable limits; this indicated that the water has normal level of pH that prevents solubility of metals. Besides, less pH than 6 mh/L affects metabolic activities of aquatic organisms (Fakayode, 2005). Identical observation was made by Ebenebe et al. (2016) Bisht et al. (2013), Oyedibu et al*.* (2016) and Oladele and Olatunde (2012) in their study sites, but digressed report was reported by Ghulam et al*.* (2014), Shubam et al. (2017). TA is a buffering ability of any water body which lowers pH. TA for the present study was higher in all stations and fell within the acceptable standards. The higher value of TA in this study indicates self control of water hardness. When water body is soft it allows varieties of organisms to thrive very well in it. The value range of TA in this study is higher compared to the values reported by Francis et al. (2007), Bisht et al*.* (2013) and Oyedibu et al*.* (2016) while value of TA for the present study is lower compared to the value range reported by Shubam et al*.* (2017).

Total Dissolved Solids (TDS) observed in this study were high in the outlet and reservoir stations which could be attributed to anthropogenic input and runoff. The water quality of Erelu has moderate dissolved solid, which indicates low nutrient and hardness, because the values are not beyond the limits of WHO and NESREA. The value of TDS is lower compared to TDS reported by Popoola and Inwang (2016) and Oyedibu et al*.* (2016). Contrasting observation was reported by Ebenebe et al. (2016). Electrical Conductivity that was less in the outlet station and high values in the reservoir and inlet stations could be due to water movement that neutralizes the salt because EC is a measure of TDS. The present study showed EC value that is higher compared to the value reported by Ebenebe et al. (2016) and Oyedibu et al*.* (2016) while Popoola and Inwang (2016) reported marked variation of EC value in Alaro stream, Ibadan, Nigeria.

The Hemiptera and Coleoptera that recorded high percentage in this study indicates the availability of good vegetation that serves as breeding sites, food and DO that is moderate in the water body. Their presence also tells the condition of the reservoir as being fair or moderately polluted because they can tolerate fair degradation of water body. This is further confirmed by the complete absence of sensitive species of pollution index such as Ephemeroptera, Plecoptera and Trichoptera throughout this study. Same observation was reported by John and Ebehiremhen (2015) and Purkayastha and Gupta (2012). Contrary observation was reported by Payakka and Prommi (2014) who reported low abundance of Hemiptera and Coleoptera, while Trichoptera was reported to have highest percentage. They also reported low percentage of Diptera and Odonata as similar to the present study. The positive significant ($P<0.01$) relationship of transparency with Hemiptera and Odonata revealed the reservoir to have better light penetration which is the reason for high levels of transparency in the reservoir and also indicated high productivity due to active photosynthesis as a result of light which in turn leads to the abundance of the organisms. The turbidity that related positively with Diptera ($r=0.731^*$) showed that there is high suspended particles sometimes in the reservoir especially during rainy season which affects the DO circulation and since Diptera can survive in a low oxygen environment; it has great impact on its abundance. Similar observation was made by Akaahan et al. (2014). Dissolved oxygen that had inverse relationship with Diptera indicated no impact on the abundance of the organisms, since it can survive in low oxygen (hypoxia) area. Ca^{2+}, PO_4^-, TDS, Temp. and EC that related inversely with Diptera may be associated with moderate and required value limits of these parameters and less input of industrial wastes. Similar observations were made by Owojori et al*.* (2006), Akhaan et al*.* (2014) and Popoola and Inwang (2016), where they reported some of these parameters being related with a few insects like *Sphaeridium* sp. *Chironomus* sp.

Turbidity, Mg^{2+}, NO_3^-, DO, BOD and pH that related inversely with Coleoptera may be attributed to their low values recorded during study except turbidity with high values. Hemiptera positive correlation with other parameters like (Ca^{2+}, Mg^{2+}, Turbidity, NO_3^-, TDS, TA and EC) could be attributed to their presence as nutrients in the reservoir which has positive impact on its abundance. Similar result was reported by Ishaq and Khan (2014). The negative relationship of $Ca^{2+}Mg^{2+,}$ NO_3^-, TDS, TA, pH, Temperature and EC with Odonata showed that the parameters have no impacts on the abundance since they can tolerate the excesses of the parameters to some extent and maintain the required limits for aquatic life survival. It can be deduced from this study that odonata larvae has smaller percentage composition in the studied reservoir. Payakka and Prommi (2014) reported similar low percentage composition.

The Shannon and Margalef indexes showed that all sample stations were below three, which is an indication of polluted water body. Similar observation was reported by Popoola and Inwang (2016) in Alaro stream, Ibadan.

Contrary opinion was reported by John and Ebehiremhen (2015) who reported Margalef values more than 3 across stations in Obazua Lake, Benin and related to stable aquatic environment.

Conclusion

The physical and chemical parameters in this study have little influence on the abundance of insect community encountered in Erelu reservoir which may be as a result of some of the parameters having required values as recommended by international bodies. The abundance of Hemiptera and Coleoptera still reflects the moderate pollution status of the reservoir. However, low values of nutrient parameters and low percentage of pollution tolerant organisms such as *Chironomus* sp. also buttressed this fact. It is therefore, recommended that proper monitoring of the reservoir against domestic and automobile effluent input should be discouraged to prevent future deterioration of the reservoir.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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